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Vitamin D Fortification of Processed Meat to Reduce Self-reported Deficiencies: Consumer Acceptance in the Irish Market

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Vitamin D fortification of processed meat to reduce self-reported deficiencies: Consumer acceptance in the Irish market.

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ABSTRACT

It is believed that many areas of the world are experiencing a Vitamin D deficiency pandemic. With Ireland's geographic location, genetic characteristics, and the reemergence of rickets in Ireland in the early noughties; Ireland is a part of the deficiency pandemic. Vitamin deficiencies have historically been handled effectively through food fortification schemes, however additional food products, like processed meats, need to be assessed for their ability to address the deficiency and consumer acceptance.

Aim: The aim of this study is to analyse the general consumer acceptance of future Vitamin D fortified, processed meats in the Irish market, in order to reduce deficiencies.

Methodology: This study used primary data gathered on an online survey platform. All variables were self-reported, opinion-based, and multiple choice. Variables pertained to demographics, vitamin D intake, food fortification, and processed meats. Chi Squared tests were used to test the relationship between Vitamin D and fortification, fortification and processed meat consumption, etc.

Results: The majority of respondents believed that they do not have an adequate intake of Vitamin D, consumed processed meats and an overwhelming majority of respondents also agree with food fortification. The significance of relationships between variables and the percentages of certain responses were tested to make assumptions on the consumer acceptance and impact on Vitamin D deficiency reduction. There was a significant relationship between those who consume processed meats and those that agree with fortification. There was also a significant relationship between those that think their health would increase with increased Vitamin D intake and those that would consider buying processed meats fortified with Vitamin D. The relationship was also

significant between those that regularly purchase fortified foods and those that would consider buying fortified meats fortified with Vitamin D.

Conclusion:

This finding of this study speaks to the possible success and reach of Vitamin D fortified processed meats. However, while correlation is plausible, the findings were not significant enough to declare that this product would be widely accepted in the market or would have a notable reduction on the population's Vitamin D deficiency.

DECLARATION

I hereby certify that this material, which I now submit in part fulfilment of the requirement for the award of MSc in Food Safety Management, is entirely my own work and has not been taken from the work of others save and to the extent such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the guidelines for dissertation production in the M.Sc. Food Safety Management and has not been submitted in whole or in part for an award in any other Institute or University.

The work reported on in this thesis conforms to the principles and requirements of the Institute's guidelines for ethics in research.

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TABLE OF ABREVIATIONS

CSO:	Central Statistics Office
EC:	European Council
EU:	European Union
FSAI:	Food Safety Authority Ireland
HSE:	Health Service Executive
IUNA:	Irish Universities Nutrition Alliance
nmol/L:	Nanomoles per Litre
TILDA:	Irish Longitudinal Study on Ageing
UCD:	University College Dublin
UK:	United Kingdom
US:	United States
WHO:	World Health Organization

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SECTION 1: LITERATURE REVIEW

1.1 Literature Review Introduction

This section will outline the literature research strategy used for this study and the results of the search. A literature review was performed that has help to illustrate the history and context of this study, highlighted relevant studies and pointed out the gaps regarding consumer acceptance of fortified processed meats and Vitamin D fortification. Fortification and the use of Vitamin D as an additive has been widely used over the last decade. However, deficiencies still exist within populations. Therefore, there is a drive to develop further solutions for Vitamin D deficiencies, using fortification, that will be accepted by consumers. This study pre-emptively investigates the possible consumer acceptance of fortified processed meats amongst Ireland's consumers.

1.2 Literature Research Strategy

A literature search was conducted using PubMed, Google Scholar, and the Irish Social Sciences Data Archive. Publications were accessed online using Technological University Dublin's subscriptions. In PubMed, only free text was used. The literature research strategy consisted of searching for literature under various headings, including: history of fortification, fortification in the EU and Ireland, Vitamin D and Vitamin D deficiencies in Ireland, processed meats in Ireland, fortification of processed meats, and consumer acceptance of "healthier" processed meats.

The goal was to set forth a background and analyse reasoning for adding a Vitamin D fortification program for processed meats in Ireland and past global experiences and acceptance of fortification of meat products. Consumer diet data is quickly changing in this decade and therefore the most current studies on meat consumption were sought out, however few results were returned.

1.3 History of Fortification

Historically, food fortification has been used as a tool by health professionals and governments to combat population-wide nutritional deficiencies. Codex Alimentarius general principles define fortification as "the addition of one or more essential nutrients to a food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups" (Commission, 1987).

Fortification can expand key nutrients of the staple substance or introduce new nutrients that chemically assimilate well in that product (Yasmeena Jan, 2019). This idea dates to 4000 BC, when a Persian physician added fillings of iron to sweet wine to boost sailor's resistance to spears and arrows (Yasmeena Jan, 2019). While fortification was farfetched at that time, more modern attempts at fortification have proven successful. In the 1920's in America, fortifying table salt with iodine reduced the widespread outbreaks of goitres. This was followed by fortifying milk with Vitamin D in an effort to prevent rickets in children (Maria de Lourdes Samaneigo-Vaesken, 2012). Folic acid has also been a major focal point of deficiencies and fortification recently (Yasmeena Jan, 2019). While past successful attempts have been made with Vitamin D fortification in select countries, a deficiency remains strong in other parts of the world.

In today's world, food fortification addresses wide spread nutritional deficiencies in a select market or region, while meeting consumer needs and preferences, and also complying with nutritional, regulatory, and food safety and technical restraints (Maria de Lourdes Samaneigo-Vaesken, 2012). It was introduced to combat some of the nutrients that are lost during modern processing techniques. Under Codex general principles, fortified foods must be stable during all processes including: manufacturing, packaging, storage, transportation and distribution to the end consumer (Commission, 1987).

Technological and developmental issues complicate the idea of food fortification, as stability of labelled levels of the nutrient and physical properties, like taste and cooking characteristics and sensory properties can be modified by the addition of nutrients that do not compliment the food product (Food Fortication Resource Center, 2018). There is a current divide between traditional fortification of finished food products during manufacturing and biofortification at the rendering phase of production.

There are different methods of implementing food fortification initiatives. Mass fortification is industry driven; where nutrients are added to foods that are consumed by the majority of the population, such as grains or dairy (Yasmeena Jan, 2019). Mass food fortification prompts the idea of mandatory fortification at the manufacturing level, whereas legal regulations have implemented food fortification as a requirement. It works best when implemented into staple foods within the region's diet. Greater than 67 countries worldwide have mandatory fortification of certain staple foods (Maria de Lourdes Samaneigo-Vaesken, 2012), as each country has the authority to dictate what is pertinent for their population.

In developed countries, market-driven fortification is a more common method of combating nutritional deficiencies with fortification as it is voluntary. Market driven fortification should be aligned with local government policies to best combat micronutrient deficiencies within a target population. Documented evidence of the deficiency, apparent connection between the deficiency and the chosen food or beverage product in the target population, and the expected benefits are necessary before implementing a market-driven fortification scheme (Barclay, 2018). In Europe, due to cost, safety and technology, processed foods are the most common example of market driven fortification (Yasmeena Jan, 2019). Lastly, target fortification focuses on a singular food item for a small target population, such as adding iron to infant formula

(Yasmeena Jan, 2019). This study will focus on the market driven fortification scheme, as it is the most likely to be accepted and utilized in Ireland.

1.4 EU and Ireland Fortification Programme

Internationally, Codex Alimentarius, the Food and Agriculture Organization and the World Health Organization have constructed general guidelines for the addition of vitamins and minerals for foods (Maria de Lourdes Samaneigo-Vaesken, 2012). Within the European Union, Regulation EC 1925/2006 regulates the "addition of vitamins and minerals and of certain other substances to foods" (European Parliament and Council, 2006). This legislation mandates that the nutrients added to a food stuff must be in a format that is bio-available to the human body (Ireland, 2009). The nutrient must also fit into one of the three following scenarios: a deficiency of one or more vitamins or minerals in the general or target population that can be shown through clinical or sub clinical evidence or indicated by estimated low levels of intake of nutrients, it contains the potential to boost the nutritional status of the general or target population and/or correct deficiencies in dietary intake due to modifications of dietary habits, or pertains to "evolving generally acceptable scientific knowledge" on the connection between vitamins and minerals in diets and the consequences on human health (Ireland, 2009).

Regulation 1925/2006 also prohibits fortification of unprocessed food stuffs and of beverages with an alcohol content above 1.2% (European Parliament and Council, 2006), thereby limiting the available options of food products available for traditional fortification. This regulation was later amended by Regulation EC 108/2008 to aligned it with the new regulatory committee. Regulation EC 1925/2006 suggests that as member states have different nutritional deficiencies at national or regional levels, mandatory fortification across the EU is not justified, however they do reserve the right to do so if it becomes necessary (European Parliament and Council, 2006).

Ireland's history with fortification is one of choice, as no mandatory, mass food fortification schemes are currently in place. According to Rosenberg, food fortification is a good strategy to promote adequate intake of nutrients, because it has the advantage of being able to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns (Rosenberg, 2007). Within Ireland, market-driven fortification is used, however, cultural acceptance has historically leaned towards products without additives. According to Bord Bia, "Cleaner labelling is an issue for today's consumer. A clean label focuses on having fewer ingredients that are very clear about their origins and are recognisable to consumers. Consumers are showing a strong desire for increased transparency from companies in food production" (Bord Bia, 2019). Therefore, cultural acceptance and public awareness plays a key role in the success of fortification programmes within the state. Vitamin D fortification within the state has been focused on the dairy industry, with milk, margarine and infant formula being the main vehicles, however liberal voluntary Vitamin D fortification of a small variety of food products currently occurs in Ireland.

There has been a push for a wider range of foods to be fortified (Deane, 2017). Vitamin D's fat-soluble nature has led it to be historically paired with animal proteins for the use of fortification. In the Irish market, the consumer has a variety of traditional and value-added choices when purchasing dairy, with Vitamin D added as a frequent option. However, the persistence of Vitamin D deficiency along with the availability of products beg the question as to if the right products or methods are being chosen or if the range of availability is sufficient.

1.5 What is Vitamin D and Vitamin D deficiency in Ireland?

Vitamin D refers to a family of fat soluble metabolites (Maria de Lourdes Samaneigo-Vaesken, 2012), that are "a key regulator of bone metabolism, calcium, and

phosphorous homeostasis" (Yasmeena Jan, 2019). The body can take in Vitamin D through sunlight, food products naturally containing Vitamin D, those fortified with it, and through supplements. Sunlight exposure is geographically dependant and taking supplements "requires people to take an active role" (Jahna, et al., 2019). Vitamin D deficiency is less in areas with higher levels of sunlight, however with Ireland's geographic location, this method of intake is limited.

There are various active forms of Vitamin D that the body can process. The physiologically active form of Vitamin D is the 1.25-dihydroxidyvitamin D_3, (Maria de Lourdes Samaneigo-Vaesken, 2012), however meat contains the 25-hydroxyvitamin D metabolite which has shown to have quicker absorption rates in humans (Duffy, et al., 2018).

A lack of Vitamin D can be linked with various health impairments, due to its connectivity with Calcium. There is increasing evidence that Vitamin D deficiencies can be linked to other conditions such as: cardiovascular disease, diabetes, depression and multiple cancers. Without adequate amounts of Vitamin D, the small intestine will only be able to absorb 10-15% of dietary calcium (Maria de Lourdes Samaneigo-Vaesken, 2012). Vitamin D is usually expressed as International Units or as "µg" micrograms (Yasmeena Jan, 2019). According to the Institute of Medicine in the USA, Vitamin D deficiency can be defined as a 25-OH-D concentration of <30 nmol/L, while recommending that individuals up to age 70 consume 15-20 µg/day (Medicine, 2011). Europe set a lower requirement for deficiency at <25 nmol/L, while the WHO set a deficient level at <25nmol/L and <50 nmol/L as inadequate (Duffy, et al., 2018). From this we can gather that the Endocrine Society task force's recommendation of 75 nmol/L daily consumption would fit in line with other scientific analysis (MF Holick, 2011).

Findings based on data from the National Food Consumption Database in 2004 found that fortification brings benefits, with a low risk of excessive nutrient intakes (Consumer Association of Ireland, 2008). According to Katherine Ketarsky R.D. L.D, at Mayo Clinic, Vitamin D toxicity due to overconsumption is rare, but can be potentially serious. However, toxicity is usually caused by overdosing on Vitamin D supplements, as the body is able to naturally regulate how much Vitamin D it takes in through sunlight and fortified foods do not contain large doses at once. Mayo Clinic says that "taking in 60,000 international units (IU) a day of Vitamin D for several months has been shown to cause toxicity" (Zeratsky, 2018) This value is 100 times the recommended daily consumption, which fortification schemes are based off.

It is believed that many countries are "currently amid a Vitamin D deficiency pandemic" because of low levels of sunlight exposure (Jahna, et al., 2019). Vitamin D deficiencies are widespread across the adult population in Europe, especially the elderly. Historically, Ireland has battled with severe vitamin deficiency due to its geographic location and insufficient sunlight to permit synthesis. In the winter months, October through March, the levels of UVB at greater than 40 degrees North are not strong enough to trigger Vitamin D synthesis (Duffy, et al., 2018). Personal characteristics like skin pigmentation, clothing style, lack of outdoor activity all also play a role in the low levels of Vitamin D synthesis and deficiencies of the vitamin in Ireland (Duffy, et al., 2018).

Vitamin D deficiency was thought to be eliminated in Ireland after World War II, through dietary improvements, however in the early noughties a re-emergence of rickets was discovered in Irish infants that pointed out extensive Vitamin D deficiencies across the state (Ireland, 2018). Rickets is a severe form of Vitamin D deficiency that causes bone deformation. Following these findings, Recommendation for a National Policy on

Vitamin D Supplementation for Infants in Ireland were created by the FSAI, to provide a national standard on this topic (Ireland, 2007). While fortification of infant formula has proven beneficial for infants in Ireland, the health of children and adults in the nation are still at risk.

There is a dearth of information on the exact levels of Vitamin D deficiency in Ireland. In a study conducted in 2006, in the Irish Medical Journal, females and males of various age groups were observed for Vitamin D deficiency. Between 4-19% of females and 7% of men had mild Vitamin D deficiency in the late summer. While during the late winter months, depending on the age group, 32-55% of females had mild deficiency, 2-30% of females had moderate deficiency and 33% of men had mild Vitamin D deficiency (Hill, et al., 2006). Following this, using blood samples from the National Adult Nutrition Survey, Cashman et al. found that 75.6% of samples had <75 nmol/L of Vitamin D, the recommended daily value, in the summer and 84% in the winter. However, if inadequate is <50 nmol/L daily intake, then their study found that 40.1% in the summer and 55% in the winter were intaking inadequate amounts of Vitamin D (Cashman, et al., 2012).

According to The Irish Longitudinal Study on Ageing (TILDA), by Trinity College Dublin, Vitamin D deficiency was common among Irish adults over the age of 50 for the first time in 2017. The study discovered that while Vitamin D deficiency is a population wide issue, there are wide variations in the levels of deficiency across the Irish provinces that can be attributed to differing lifestyles (Deane, 2017). The traditional Irish diet does not include sufficient levels of foods that contain Vitamin D (Ireland, 2018). For example, those living in the North and West showed the highest prevalence of Vitamin D deficiency, which corresponds with the prevalence of traditional Irish diets (Deane, 2017). The TILDA study found that one in eight older

adults were deficient in Vitamin D, which increased to one in four during the winter months. It also showed that the use of supplementation for Vitamin D is low in Ireland, with only 8.5% of the older population taking supplements for Vitamin D (Deane, 2017). Parallelly, Cashman et al.'s study in 2012 found that only 17.5% of Irish adults were taking Vitamin D supplements (Cashman, et al., 2012). While there is a laboratory test available for Vitamin D deficiency, the HSE has recommended that it not be used a general screening method and rather recommend that nutritional assessment and dietary fortification be used (HSE, 2017).

An article in the British Journal states that "a consistent supply of appropriately regulated, voluntarily fortified foods, produced under free market conditions and widely and regularly consumed by a given population group, can have a beneficial impact on public health by positively contributing to micronutrient balance and thereby reducing the risk of deficiency" (Rosenberg, 2007). It is expected that the results of this study will show that consumers in Ireland are aware of their possible Vitamin D deficiency, largely due to recent health marketing campaigns within the country and the scale of the issue. However, may not be taking supplements to alleviate the deficiency.

With the dairy industry as the main mode of supplemental Vitamin D in the diet, the Irish populations are depending on high consumption rates of fortified dairy to combat the Vitamin D deficiency. However, in recent years there has been a trend away from consumption of milk and animal dairy products. From 2018-2019 domestic milk consumption declined by 1.6% in Ireland (Central Statistics Office, 2019). A study based off the National Adult Nutrition Study in Ireland found that "dairy products are important contributors to nutrient intakes," however, dairy intakes, especially cheeses are declining in developed populations (Emma Feeney, 2015).

In a study of the New Zealand population, a country that gets about 600 more hours of sunlight a year than Ireland, it was discovered that daily fortified milk consumption was not enough to defeat deficiencies. “Daily consumption of fortified milk providing 5 micrograms a day of Vitamin D3 for 12 weeks resulted in higher 25OHD concentrations than control milk. [However], this dose was not sufficient to prevent the seasonal decline in 25OHD.” The study suggested that daily intake needed to be increased for the New Zealand population and current levels were likely insufficient for populations with low sunlight exposure (TJ Green, 2010). This again illustrates the need for the Irish population to have multiple modes and options for Vitamin D intake through fortification. The declining milk consumption along with insufficient quantities of Vitamin D in dairy products along suggest the possibility of opening Vitamin D fortification into additional markets. However, time has shown that in the absence of mandatory fortification schemes, consumer acceptance is at the forefront of determining the success of such programmes.

1.6 Meat and Processed Meat Consumption

The International Livestock Research Institute in Kenya conducted a study in which data from multiple decades was used to analyse and predict meat consumption trends to the year 2020. Globally, from 1999 to 2006, the consumption of meat increased from 230 tons to 268 tons (Jabbar, 2009). The study predicted a global increase of meat consumption; however, European shares of consumptions were predicted to decline in poultry (2%), pork (3%) and beef (2%) (Jabbar, 2009). These decreases can be contributed to changes in the European diets as well as rapid increases of meat consumption in other areas globally.

An article in Ireland’s Farming Independent stated that in 2017, Ireland saw a rise in total beef consumption of 3.1% (Donnelly, 2017). In a study by Wunsch in 2019, meat

consumption trends between 2010 and 2019 were used to forecast consumption for 2020 within the EU. While the article did not have any information specific to Ireland, it forecasted per-capita meat consumption within the EU to be at its highest in 10 years. Within the UK, a country with similar dietary habits to Ireland, per-capita consumption is also projected to increase (Wunsch, 2019). However, the article also commented that the UK saw a rapid rise in vegetarian product launches in 2018, signalling a possible change in market demand (Wunsch, 2019).

There is a shortage of recent meat consumption, particularly processed meat consumption, studies specific to Ireland. However, similarities can be drawn between the UK and Irish diets, influx of non-traditional diets and past consumption studies. According to the Agriculture and Horticulture Development Board in the UK, it was estimated that UK residents ate about 79kg of meat per person in 2016. Meat consumption over the past decade has been relatively stable (Reland, 2018). Using statistics from Defra in 2013, it was found that in the UK, uncooked bacon and ham is lagging in consumption, while purchases of cooked bacon and ham have steadily risen (Guardian, 2013).

Processed meats are convenient, cheap, and have satisfiable taste and are therefore are likely to remain present in the Western diets. IUNA's National Adult Nutrition Study found that when asked to rank food choice motives, respondents put taste as the most important and health and nutrition followed in 77% of adults (IUNA, 2011). This study also found that 47% of Irish consumers ate general processed meat products within a span of four days, additionally 73% ate bacon or ham and 39% ate sausages. On average of those that consumed these products, they took in 38g of processed meats, 26g of sausages and 28g of bacon and ham. While IUNA does not have more current research available for adults in their children's study from 2017-2018, they found that 91% of

children in Ireland consume processed meat and they consume more processed meat than fresh meat. This study reported that children in Ireland consume an average daily intake of 41g of processed meat, which is only a 5g daily decline from the 2003-2004 study (IUNA, 2019).

A study conducted by Teagasc in 2017 categorized the respondents of the National Adult Nutrition Study into six distinct segments. The "processed pork indulgers" made up 13% of the sample population and was mainly comprised of men from lower socio-economic backgrounds. The "chicken eaters" group comprised of 20% of respondents had high reporting levels of consuming processed chicken. Meanwhile, the groupings "all things meat" at 4% and "beef focused" at 21% all would have consumed more moderate levels of processed meats in their diets (Teagasc, 2017). While these segments show the focus and similarities of a group of people, it does not mean that those in other groupings do not also consume the product.

It is expected that consumers in Ireland will report lower rates of processed meat consumption, largely due to trends in increasing health and nutrition and the rise of vegan and vegetarianism. However, with this decrease, it is expected that a majority of consumers in Ireland still will report consuming processed meats.

1.7 Fortification of Processed Meats-History and Possibility

The idea of adding to a meat product is new in nature and within Ireland is being practiced through alterations to animal feed. However, the retention rates of nutrients in animal feed presenting in final meat products are not widely known, leading reliance to remain on traditional, after-rendering fortification.

A study was conducted in Finland on Vitamin D supplementation in the form of 25-OH-D(3), of chicken feed and its effect on Vitamin D content of yolks and chicken meat. It was found that 25-OH-D-3 was effectively transferred from the animal's diet to the

yolk, however, because the relative activity between 25-OH-D(3) and Vitamin D is unknown, it cannot be determined that this increases human intake of Vitamin D from the poultry and egg products (Mattila PH, 2011). According to a study at University College Dublin, introducing bio-actives during processing, rather than through the animal's diet offers tighter control over quantities distributed and costs (Grasso, et al., 2014). Therefore, for the purposes of this study, the focus will be on after rendering fortification of Vitamin D.

Globally, there has been considerable research in recent decades concerning enriching processed meats with healthy ingredients. Research has looked into adding Omega-3s probiotics, dietary fibre, etc into meats to boost the health catalogue. Decker and Park believed that meats could be an excellent candidate for fortification due to also containing important nutrients, like fatty acids, minerals, dietary fibre, and antioxidants (Decker, 2010). However, labelling laws have historically discouraged the fortification of processed meats. One important aspect of labelling and consumer acceptance of fortification is that the label must not imply that eating "a balanced diet cannot provide adequate levels of the added nutrients or mislead the consumer regarding the nutritional merits of the food" (Consumer Association of Ireland, 2008). Therefore, with processed meats, one may label with added Vitamin D, but cannot obscure the levels of unhealthy fats and salt in the product.

According to Duffy et al, in order to accommodate dietary diversity, innovatively designed sustainable natural Vitamin D enriched food types are required which will cover a range of food types, reflective of different dietary patterns" (Duffy, et al., 2018). As meat is one of the few foods that has naturally occurring Vitamin D (S.A. Sofi, 2017), and has a high consumption rate within the EU at 67.9kg/capita (Duffy, et al., 2018) it is a considerable choice for future fortification programs.

Processed meat includes meat that has been preserved by curing, smoking, or salting, or by addition of chemical preservatives. Minced meat can be considered processed if it has been preserved chemically (Fund, 2007). Processed meats have been largely deemed unhealthy by the scientific community, with the International Agency for Research on Cancer labelling processed meats as a group 1 carcinogen (Society, 2015). Despite its negative aspects, processed meat makes up a large percentage of the meat regularly consumed (Bolger Z, 2016).

When looking into the possibility of fortifying processed meats with Vitamin D, retention rates are of concern, as most items fortified with Vitamin D are not cooked. A study at the Technological University of Denmark looked into retention rates of Vitamin D fortified margarine, eggs and bread. This study found that 82-84% of Vitamin D was retained in these products when cooked via frying pan, however loses were more significant when cooking in the oven (Jakobsen, 2014). In a similar study, by Matilla et al., which looked into the effects of household cooking on Vitamin D in fish and egg yolks, it was found that the losses of Vitamin D compounds were <10%. They stated that "household cooking would seem not to lessen intake of Vitamin D from foods" (Pirjo Mattila, 1999). As processed meats, like sausages and rashers, are generally cooked in the frying pan, the lose of the fortified Vitamin D during the cooking step will be present, but not detrimental. Adequate amounts would have to be added into the food products, relating to the recommended daily values, to take into account the potential loses.

1.8 Consumer Acceptance of Fortified Processed Meats

Consumer acceptance of fortified processed meat products is a vital aspect in the effect that the fortification program will have on the reduction of Vitamin D deficiencies in Ireland. Ultimately, the consumer has to buy and consume the products for them to do

their job. A study published in Appetite Journal, from 2019, looked into "how attitudes on fortification can lead to purchase intentions," with Vitamin D fortified foods of animal origin including processed meats. The results of this study found that attitudes towards food fortification are highly associated with perceived personal benefit, especially when consumers are highly aware of the deficiency rates.

Purchase intention also depends on the perceived appropriateness of the product being enriched. When consumers saw the product and fortifying nutrient as a good combination, it offset effects associated with low deficiency awareness (Jahna, et al., 2019). In Jahna et al.'s study, on a sliding scale of 1-7, Vitamin D fortification of sausages was ranked low in appropriateness, at about 2.8. Liver Pate was slightly higher at about 3.3, while milk was the highest at about 4.6 (Jahna, et al., 2019). This varies culturally though, as this study was conducted for the Danish population. For example, as mentioned above, Vitamin D food fortification of dairy products has increased intake successfully in America and also in Finland, but it has had much less of an effect in Sweden (Jahna, et al., 2019).

Consumer acceptance is not purely scientific and is something that is not fully understood yet. The study ultimately suggested that a combination of positive attitude towards food fortification, awareness of Vitamin D deficiency and perceived appropriateness of fortification for the product are all required aspects in getting consumers to purchase the fortified food product (Jahna, et al., 2019).

There are few comprehensive studies on the consumer acceptance of functional meat products, especially those related to fortification by addition. According to Hathwar et al., in their review of consumer acceptance of healthier meat products, developing and marketing novel, functional meat products is unconventional and consumers in many

countries may not consider these products in the same manner that they would dairy or cereals (Hathwar, et al., 2012). Opinions of functional and fortified foods vary greatly by the country. In Japan the functionality of a product is said to outweigh the importance of taste, while in the US and Europe the functionality of a product does not distinguish it from another to consumers (Grasso, et al., 2014). In North America, there are been increasing trends in the demand for processing and convenience, as cooking skills and time allowance decrease (Ahmed & Anders, 2012).

There is a belief amongst many consumers that meat in a pure and unaltered state is of the highest quality. This is shown through many failed attempts at the product development of healthier meat products, but according to Hathwar et al., "the success or failure of the functional food is dependent on salient features of the product, its commercial viability and, on the nature, extent and management of collaboration between related disciplines [food technologists, nutritionists, product chemists etc]" (Hathwar, et al., 2012).

Liran Shan and Aine Regan of UCD School of Public Health conducted a qualitative study titled "Consumer Views on 'Healthier' Processed Meats" in Ireland, which aimed to investigate consumer attitudes on "functional processed meats". This study defined "functional processed meats" as "processed meat enriched with healthy ingredients that provide health benefits beyond the basic nutrition of the meat products" (Liran Shan, 2016). In this study, participants were weary, logical and hopeful at the prospects of making processed meats healthier. In this qualitative study of forty participants, only one person suggested fortifying processed meats as a way of making them healthier (Liran Shan, 2016). When asked directly about adding healthy ingredients to processed meats, participants were uncomfortable with the idea of meat being a carrier of extra ingredients, mainly due to low familiarity and distrust in meat producers (Liran Shan,

2016). While the participants in this study displayed a negative reaction to fortified processed meats at the idea stage, it ultimately still illustrated the want of the Irish population to be able to consume processed meats and positively impact their health at the same time. With it, Irish food producers and public health officials are still left with the question as to if fortified processed meats could succeed in the market.

Looking into other international studies, according to Grasso et al., multiple studies across the world have shown that consumers have reported that enrichment of foods deemed as unhealthy is more justified than enrichment of healthy foodstuffs (Grasso, et al., 2014). A consumer acceptance study in Denmark discovered that "the perceived fit between ingredient and carrier product was a stronger predictor of purchasing decision than health concerns" (Grasso, et al., 2014). Also, Poulsen found that views on enrichment were generally more positive when the carrier product already contained the fortification substance (Grasso, et al., 2014). Thus, as meat is a natural carrier of Vitamin D, there is a potential for consumer acceptance of further Vitamin D fortification of meat. In a 2014 study by Tobin et al., the attitude of over 500 Europeans towards functional (or fortified) processed meats was analysed. This study found that consumers were unsure on their views on adding bioactive compounds to meat, as this was something they were unfamiliar with. However, 60% reported that they would consume a functional processed meat, but not pay more for it, while 40% were willing to consume and pay more (Tobin, et al., 2014)

In order to drive consumer acceptance of fortified processed meats, one will first have to tackle the unhealthy public perception of processed meats. Grasso et al. suggests that bringing fortified meat into market will require that there is no compromise on taste, a strong brand, compliance with regulations, cost effectiveness at production stages and ultimately an acceptable retail price (Grasso, et al., 2014). A study by Hung, that looked

into adding phytochemicals into processed meat, reaffirms this belief in concluding that "to be successful, the meat products with added phytochemicals would have to possess desirable sensory characteristics and proven health benefits compared with regular meat products" (Liran Shan, 2016).

While studies, like the ones mentioned above, have entertained the idea of fortifying processed meats, or making them healthier, none have looked specifically into the Irish market. Fortification schemes success is very culture and market dependent, requiring specific research prior to implementation. This study will take some of the first steps in gaining information on the acceptance of Vitamin D fortified, processed meats by consumers living in Ireland.

Aims and Objectives

The aim of this study is to analyse the general consumer acceptance of future Vitamin D fortified, processed meats in the Irish market, in order to reduce deficiencies. The objectives will be to collect data through a random selection, online questionnaire amongst Irish consumers and describe the acceptance of Vitamin D fortified processed meats against demographic data points. The goal is to suggest if fortified processed meats would be accepted in the Irish market to reduce deficiencies. This study seeks to answer the following questions:

1. Do Irish consumers think they are deficient in Vitamin D or think they could improve their health with increased intake?
2. Do Irish consumers agree with fortification? Do these consumers that agree eat processed meats?
3. Would consumers buy more processed meat if it had a health benefit?

4. Would consumers buy processed meat fortified with Vitamin D? Are the consumers that would buy Vitamin D fortified processed meats the same consumers that think they are deficient in Vitamin D?

SECTION 2: METHODOLOGY

2.1 Study Design

This study is based off of primary data gathered over the course of three concurrent weeks in November 2019. Original primary data was collected for the purposes of this study and was analysed using SPSS Version 24 software. The below sections go into further detail on the research methods performed.

2.2 Target Population

The study target population consists of consumers living in the Republic of Ireland. All ages and genders are equally sought after. As the survey was web based, no specific groups of the population were targeted. According to the Central Statistics Office of Ireland, the estimated population for April 2019 was 4,921,500 people (Central Statistics Office, 2019). As the most recent census population was 4,761,865 in 2016 and immigration has spiked since those years, the estimates were used for the purposes of this study.

To calculate the target sample size the standard sample size formula was used, whereas n equals population size, e equals margin of error and p equals z scores in relation to confidence levels.

$$\text{Sample size} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

Figure 1-Sample Size Formula (Survey Monkey, 2019)

For the population size, at 4,921,500, and 95% confidence with a 5% margin of error the target sample size for this study was calculated as 385 respondents.

2.3 Sampling Strategy and Study Population

The data that was used in this study is drawn from original survey responses gathered for the purposes of this research. The study included consumers residing in the Republic of Ireland, of all ages and genders. The inclusion of all consumers was meant to create a diverse representation of both rural and suburban consumers, age brackets, incomes and viewpoints. By doing so, it illustrates the shoppers of a general grocery chain, like Tesco, Lidl, Aldi etc in Ireland and the consumers of Irish made products. In order to better represent the day to day Irish market, respondents that reported not living in Ireland were excluded from the study sample.

A random convenience sampling strategy was used to collect responses. The questionnaire was published using an online survey platform, SurveyMonkey. Links from this platform to complete the survey were then posted into Irish-based Facebook groups, Twitter and LinkedIn. The Facebook groups included but were not limited to Expats in Ireland, Americans in Ireland, UCD Students, and Girl Crew. The survey link was also sent out to friends and colleagues of the researcher; who then further distributed the survey to their friends, family and colleagues. Respondents completed the survey using their own devices. Due to the nature of this survey, the setting and outside influences could not be controlled. Using this strategy, 392 responses were collected within three weeks. Responses which did not complete all non-demographic questions were removed from the sample, prior to analysis. Four responses were removed, leaving 387 samples.

The sample population from this survey represented the target population numbers well. Due to the nature of collection, the population favours female representatives. The study population consisted of 76% females, 23.7% males, and .3% other. The age brackets used did not consist of equal years, therefore the study population consisted of 2.3% at or below

18 years, 20.4% between 19 and 25 years, 64.2% between 26 and 55 years, and 13.1% above 55 years.

2.4 Data Collection and Study Instruments

Data collection was started on November 17th, 2019 and ended on December 7th, 2019. No vulnerable groups or details were requested, therefore ethical approval was not requested. The data was secured through the Survey Monkey platform until the end of the collection period, at which point it was exported to excel and uploaded to SPSS. Data was secured on a password protected computer and was analysed using SPSS version 24 software. Identities were masked on the Survey Monkey platform, by giving each respondent a unique 11-digit respondent ID. This ID was used during export and analysis as well.

The data was collected through online survey requests, through social media and local connections. Respondents were informed that this data was to be used as a part of a master's thesis and all responses would remain anonymous. The questionnaire was comprised of 11 multiple choice questions. Every respondent received the same questions in the same order, to ensure validity and consistency. See Appendix 1 for the online survey. All variables were self-reported opinions and estimates. Nominal, Yes/No measurements were used for the variables.

2.5 Statistical Analysis

A total of 11 variables about demographics, vitamin D intake, supplementation, fortification and processed meat from the questionnaire were used in this study. Age was categorised as 0-18, 19-25, 26-55 and 55+. All other variables were yes/no responses. No variable forms were altered following collection. Because of the nominal nature of the variables, Chi Squared Tests were used for all comparative analysis.

SECTION 3: RESULTS

3.1 Introduction to Results

This chapter covers the results obtained from the analysis of the sample data. The demographic data in this study is limited; with Table 3.1 highlighting what data was available. This study was comprised of 387 consumers living in the Republic of Ireland of varying genders and ages. Tables 3.2-3.7 use Chi-Squared tests to run comparative analysis on answers to questions related to Vitamin D consumption and fortification of foodstuff and age and gender. Table 3.2-3.4 presents data related to Vitamin D and health, while 3.5-3.7 present data related to fortification and processed meats. Tables 3.8-3.10 present a comparative analysis of the question responses in relation to health, fortification and the acceptance of Vitamin D fortified processed meats, using Chi-Squared tests. Tables 3.11-3.12 run further comparative analysis by looking into the consumer acceptance of processed meats as a carrier for Vitamin D fortification.

3.2 Sample Population and Descriptive Statistics

Table 3.1 below presents the descriptive statistics on the study population.

Table 3.1: Descriptive Data on Demographics of the Sample Population

	Valid Denominator	n	%
Where do you reside?	387		
Ireland		387	100.0%
Gender	387		
Male		92	23.8%
Female		294	76.0%
Other		1	0.3%
Age	387		
0-18		9	2.3%
19-25		79	20.4%
26-55		248	64.1%
55+		51	13.2%

As seen in Table 3.1 above, all study participants resided in Ireland as those who responded with other were removed from the study. The study had an overwhelming majority of female responses. It was comprised of 76.0% females, 23.8% males, and 0.3% who responded as "other" gender. The age demographics were varied amongst the differing sized brackets. The majority of respondents were between the ages of 26 and 55 at 64.1%, followed by 19-25 at 20.4%. These details can be found in Table 3.1.

3.3 Comparative Analysis

Initially this study wanted to see if Irish consumers believe they have an adequate intake of Vitamin D, if they are adding to their intake with supplements, if they believe they could benefit from increased intake, if they agree with fortification and purchase fortified food products and if they eat processed meats.

Tables 3.2-3.7 show this data in various forms. Each of these tables demonstrate an answer to a question against demographic points. Table 3.2, below, presents the findings following comparative analysis of belief of adequate intake of Vitamin D by gender and age.

Table 3.2: Ireland Consumer's Belief of Adequate Intake of Vitamin D by Gender and Age

		Do you believe you have adequate intake of vitamin D?				
	Valid Denominator	**Yes**		**No**		
		n	%	n	%	
Gender	387					
Male		46	50.0%	46	50.0%	
Female		119	40.5%	175	59.5%	
Other		1	100.0 %	0	0.0%	
	Percentage of Total		42.9%		57.1%	**p-value***
						0.140
Age	387					
0-18		5	55.6%	4	44.4%	
19-25		35	44.3%	44	55.7%	
26-55		106	42.7%	142	57.3%	
55+		20	39.2%	31	60.8%	
	Percentage of Total		42.9%		57.1%	**p-value***
						0.816

* Pearson's Chi-Squared

In the table above, regarding the belief of adequate intake of Vitamin D insignificant differences were noted between males and females (p=0.140). Males were equally divided on there views regarding their intake of Vitamin D, while the majority of women felt they do not take in an adequate amount of Vitamin D. The relationship between age and a belief of adequate intake of Vitamin D were also insignificant. All age groups, except the lowest bracket, 0-18, had a majority report that they do not believe they have

adequate intake of Vitamin D. The difference was strongest in the older age bracket, 55+, where 60.8% reported not having adequate intake of Vitamin D. Overall 221 people reported inadequate intake, while 166 reported they believe their intake is adequate.

Table 3.3 below presents the findings following comparative analysis of consumers reported Vitamin D supplementation habits by gender and age.

Table 3.3: Irish Consumer's Vitamin D Supplementation by Gender and Age

		Do you take Vitamin D supplements?				
	Valid Denominator	**Yes**		**No**		
		n	%	n	%	
Gender	387					
Male		41	44.6%	51	55.4%	
Female		137	46.6%	157	53.4%	
Other		0	0.0%	1	100.0%	
	Percentage of Total		46.0%		54.0%	**p-value*** 0.616
Age	387					
0-18		2	22.2%	7	77.8%	
19-25		32	40.5%	47	59.5%	
26-55		121	48.8%	127	51.2%	
55+		23	45.1%	28	54.9%	
	Percentage of Total		46.0%		46.0%	**p-value*** 0.284

* Pearson's Chi-Squared

In the table above, there are insignificant relationships between gender and Vitamin D supplementation as well as age group and Vitamin D supplementation (p=0.616 and p=0.284). In both male and female genders, there is a near equal reporting of taking Vitamin D supplementation and not taking any, with the slight majority not taking supplements in both groups. In all age brackets the majority do not take Vitamin D

supplements, with the largest difference showing in the lowest age bracket, 0-18, at 77.8% not taking supplements. Overall, only 46% of respondents reported taking Vitamin D supplements.

Table 3.4 below presents the findings following comparative analysis of consumers reported belief of an increase in health by increasing Vitamin D consumption by gender and age.

Table 3.4: Irish Consumer's Belief of Health Increase with Vitamin D Increase by Gender and Age

		Do you believe an increase of Vitamin D intake would benefit your health?				
	Valid Denominator	**Yes**		**No**		
		n	%	n	%	
Gender	387					
Male		66	71.7%	26	28.3%	
Female		250	85.0%	44	15.0%	
Other		1	100%	0	0.0%	
	Percentage of Total		81.9%		18.1%	**p-value*** 0.014
Age	387					
0-18		6	66.7%	3	33.3%	
19-25		71	89.9%	8	10.1%	
26-55		197	79.4%	51	20.6%	
55+		43	84.3%	8	15.7%	
	Percentage of Total		81.9%		18.1%	**p-value*** 0.111

*Pearson's Chi-Squared

In the table above there is a significant relationship between the belief that an increase of Vitamin D intake would benefit health and gender (p=0.014). A large majority of both genders believed that increasing Vitamin D intake would benefit their health.

Overall, nearly 82% of respondents answered that an increase of Vitamin D intake would benefit their health. However, the relationship between belief on a health benefit to increased Vitamin D intake was insignificant (p=0.111). Every age bracket responded that they would benefit from an increase in Vitamin D consumption, with 19-25 having the strongest belief with 89.9% responding yes to increased health.

Table 3.5 below presents the findings following comparative analysis of consumers reported agreement with fortification, given the Codex Alimentarius definition, by gender and age.

Table 3.5: Irish Consumer's Agreement with Fortification by Gender and Age

		Do you agree with fortification?				
	Valid Denominator	**Yes**		**No**		
		n	%	n	%	
Gender	387					
Male		74	80.4%	18	19.6%	
Female		231	78.6%	63	21.4%	
Other		1	100.0%	0	0.0%	
	Percentage of Total		79.1%		20.9%	**p-value***
						0.814
Age	387					
0-18		8	88.9%	1	11.1%	
19-25		69	87.3%	10	12.7%	
26-55		191	77.0%	57	23.0%	
55+		38	74.5%	13	25.5%	
	Percentage of Total		79.1%		20.9%	**p-value***
						0.167

*Pearson's Chi-Squared

In the table above there is an insignificant relationship between agreement with fortification and gender and agreement with fortification and age (p=0.814 and

p=0.167). In all genders, the large majority agree with fortification. There was little difference between the views of males and females regarding fortification. This majority was also shown through the majority of all age brackets reporting that they agree with fortification of foodstuffs. There was no age bracket that stood out from the views of other age brackets. Overall 79% of all respondents agreed with fortification of foodstuffs.

Table 3.6 below presents the findings following comparative analysis of consumers purchasing habits of fortified foods by gender and age.

Table 3.6: Irish Consumers' Purchasing Habits of Fortified Foods by Gender and Age

		Do you regularly purchase fortified food products?				
	Valid Denominator	**Yes**		**No**		
		n	%	n	%	
Gender	387					
Male		52	56.5%	40	43.5%	
Female		183	62.2%	111	37.8%	
Other		1	100.0%	0	0.0%	
	Percentage of Total		70.0%		30.0%	**p-value***
						0.448
Age	387					
0-18		3	33.3%	6	66.7%	
19-25		48	60.8%	31	39.2%	
26-55		154	62.1%	94	37.9%	
55+		31	60.8%	20	39.2%	
	Percentage of Total		70.0%		30.0%	**p-value***
						0.388

*Pearson's Chi-Squared

In the table above there is an insignificant relationship between purchasing habits of fortified food products and gender and purchasing habits of fortified food products and

age ($p=0.448$ and $p=0.388$). A slightly higher percentage of women regularly purchase fortified food products than men. However, overall both genders responded that the majority do regularly buy fortified food products. When divided by age, the 0-18 age bracket responded that only 33% regularly purchase fortified food products. While all older age brackets responded with a majority regularly purchasing fortified food products. Overall 61% of respondents stated that they regularly purchase fortified food products.

Table 3.7 below presents the findings following comparative analysis of consumers consumption habits of processed meats by gender and age.

Table 3.7: Irish Consumers' Consumption Habits of Processed Meats by Gender and Age

		Do you consume processed meats?				
	Valid Denominator	**Yes**		**No**		
		N	%	n	%	
Gender	387					
Male		69	75.0%	23	25.0%	
Female		202	68.7%	92	31.3%	
Other		1	100.0%	0	0.0%	
	Percentage of Total		70.3%		29.7%	**p-value***
						0.416
Age	387					
0-18		8	88.9%	1	11.1%	
19-25		56	70.9%	23	29.1%	
26-55		170	68.5%	78	31.5%	
55+		38	74.5%	13	25.5%	
						p-value*
	Percentage of Total		70.3%		29.7%	0.513

*Pearson's Chi-Squared

In the table above, there is an insignificant relationship between consumption habits of processed meats and gender and consumption habits of processed meats and age (p=0.416 and p=0.513). Seventy five percent of male respondents consume processed meats, versus 68.7 percent of female respondents. However, overall the majority of all genders consume processed meats. The youngest age bracket, 0-18, had the highest percentage of respondents that consume processed meats at 88.9%. Meanwhile, the age bracket with the lowest percentage consuming processed meats was 26-55, at 68.5%. Overall 70% of respondents consume processed meats.

Next it was important to find the relationships of respondents from one question to another. The following tables shed some light on the effect fortifying processed meats may have on Vitamin D deficiency.

Table 3.8 below presents the findings following comparative analysis of the responses of the questions “do you consume processed meats?” and “do you agree with fortification?”.

Table 3.8: Irish Consumers' Consumption Habits of Processed Meats by Agreement with Fortification

		Do you consume processed meats?				
	Valid Denominator	**Yes**		**No**		
		n	%	n	%	
Do you agree with fortification?	387					
Yes		224	82.4%	82	71.3%	
No		48	17.6%	33	28.7%	
	Percentage of Total		70.3%		29.7%	**p-value***
						0.015

*Pearson's Chi-Squared

In the table above there is a significant relationship between consumption habits of processed meats and agreement with fortification. Of those who consume processed meats, 82.4% or 224 respondents also agree with fortification.

Table 3.9 below presents the findings following comparative analysis of the responses of questions “do you believe you have adequate intake of Vitamin D?” and “would you consider buying processed meats fortified with Vitamin D?”

Table 3.9: Irish Consumers' Acceptance of Vitamin D Fortified Processed Meats by Adequate Vitamin D Intake

		Would you consider buying processed meats fortified with Vitamin D?				
Do you believe you have adequate intake of Vitamin D?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		90	54.2%	76	45.8%	
No		138	62.4%	83	37.6%	
	Percentage of Total		58.9%		41.1%	**p-value***
						0.104

*Pearson's Chi-Squared

In the table above there is an insignificant relationship between belief of adequate intake of Vitamin D and willingness to consider buying processed meat fortified with Vitamin D. Of those who believed they did not have an adequate intake of Vitamin D; 62.4% or 138 respondents would consider buying processed meats fortified with Vitamin D.

Table 3.10 below presents the findings following comparative analysis of the responses of questions “do you believe an increase of Vitamin D would benefit your health?” and “would you consider buying processed meats fortified with Vitamin D?”

Table 3.10: Irish Consumers' Consumption Acceptance of Vitamin D Fortified Processed Meats by Belief in Increased Health with Increased Vitamin D

		Would you consider buying processed meats fortified with Vitamin D?				
Do you believe an increase of Vitamin D would benefit your health?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		200	63.1%	117	37.0%	
No		28	40.0%	42	60.0%	
	Percentage of Total		58.9%		41.1%	**p-value***
						>0.001

*Pearson's Chi-Squared

In the table above there is a significant relationship between belief of increased health with increased Vitamin D and willingness to consider buying processed meats fortified with Vitamin D ($p<0.001$). Of those who believed an increase of Vitamin D would benefit their health, 63.1% or 200 respondents would consider buying processed meats fortified with Vitamin D.

The tables below research the consumer acceptance of processed meats as a carrier for Vitamin D fortification.

Table 3.11 below presents the findings following comparative analysis of the responses of questions “would you consider buying more processed meats if they had a health benefit?” and “would you consider buying processed meats fortified with Vitamin D?”

Table 3.11: Irish Consumers' Consumption Acceptance of Vitamin D Fortified Processed Meats by Willingness to Consider Buying More Processed Meats if they had a Health Benefit

		Would you consider buying processed meats fortified with Vitamin D?				
Would you consider buying more processed meats if they had a health benefit?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		183	81.3%	42	18.7%	
No		45	27.8%	117	72.2%	
	Percentage of Total		58.9%		41.1%	**p-value*** >0.001

*Pearson's Chi-Squared

In the table above there is a significant relationship between willingness to consider buying more processed meats if they had a health benefit and willingness to consider buying processed meats fortified with Vitamin D ($p<0.001$). Of those who would be willing to buy more, 81.3% or 183 respondents would consider buying processed meats fortified with Vitamin D.

Table 3.12 below presents the findings following comparative analysis of the responses of questions “do you regularly purchase fortified foods?” and “would you consider buying processed meats fortified with Vitamin D?”

Table 3.12: Irish Consumers' Consumption Acceptance of Vitamin D Fortified Processed Meats by Regular Purchasing of Fortified Foods

		Would you consider buying processed meats fortified with Vitamin D?				
Do you regularly purchase fortified foods?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		159	67.4%	77	32.6%	
No		69	45.7%	82	54.3%	
	Percentage of Total		58.9%		41.1%	**p-value*** >0.001

*Pearson's Chi-Squared

In the table above there is a significant relationship between regular purchase of fortified foods and willingness to consider buying processed meats fortified with Vitamin D ($p<0.001$). Of those who regularly purchase fortified foods, 67.4% or 159 respondents would consider buying processed meats fortified with Vitamin D.

SECTION 4: DISCUSSION OF RESULTS

4.1 Introduction to Discussion

This study set out to evaluate the current beliefs of consumers on Vitamin D, health, fortification and processed meats; with the ultimate aim to predict if Vitamin D fortified processed meats would be an effective solution to reduce self-reported deficiencies of Vitamin D in the Irish market. To achieve this aim, the data was analysed to find the relationships of question responses and demographics. The Vitamin D status of the population, acceptance of fortification and consumption of processed meats was assessed against different demographics and against each other. It was expected that the answers to these questions would provide insight into the consumer acceptance of Vitamin D fortified processed meats and how the addition of this product would address Vitamin D deficiencies. This insight would be useful for health officials as well as product manufacturers.

4.2 Self Reporting and Response Rates In Context

With regard to the manner in which the variables were gathered and presented, especially those which delve into the Vitamin D deficiencies of the respondents, it is important to note that these are all self-reported and not diagnostic. The total reliance on self-reported measures is a cause for concern in this study. Data from EuroStat illustrates that in 2016, 42.9% of Ireland self-reported their health as very good, behind only Greece and Cyprus, while the European Union average was only 23% (Eurostat, 2016). However, when one looks at other health measures, like Vitamin D deficiency and life expectancy, Ireland ranks only slightly above average. This trend of overestimating self-reported health could have had effects on the results of this study. While others argue this point, saying in a 1994 study that self-reporting is usually a suitable methodology for studying human characteristics, perhaps even a superior

method, as it allows room for error (Razavi, 2001). However, this study's loose definition of deficiency and basic yes and no response options help to alleviate some of the inaccuracies with self-reporting.

As the responses included in the study were limited only to those which fully completed the questionnaire, response rates were consistent with this study. The target response quota, which was based on Irelands population, was exceeded for this study. According to the National Research Council in America, survey researchers across a number of disciplines in America and abroad have witnessed a gradual decrease in survey participation over time (Council, 2013). However, the persistence of spreading this survey, easy accessibility and minimal time requirement of the questionnaire used for this study promoted a deviation from this trend and positive response rates.

4.3 Sample Population Demographics In Context

The sample size was calculated from the population of the Republic of Ireland, however demographics, beyond residence location, were unable to be managed within the study population. As can be seen in Table 3.1, the study was made up of 76% female, 23.8% male and .3% other. While actual demographics of the study population, as of 2016, consists of 49.4% male and 50.6% female, according to the CSO (Central Statistics Office, 2017).This shows a slightly disproportionate response rate from the percentage of men in the study versus the study population. Studies by Curtin et al and Turin et al, on survey response and non-response have found that women are more likely to participate than men (Smith, 2008). In a paper from University of San Jose specifically looking into online survey response rates, it was found that a disproportionately large number of women responded in comparison to the target population and men's response rates (Smith, 2008). This further shows the tendency to have a higher female response rate in the online mode of surveying.

Regarding the age groups, there were also no modes of control within this study. The sample population consisted of 2.3% 0-18 years, 20.4% 19-25 years, 64.1% 26-55 years, and 13.2% 55+ years old. There are low response rates in this study for 0-18 years old, however, as this age group rarely does the grocery shopping in a home, it is to be expected to have low responses from this ae group. It was expected that the 26-55 years old age group would consist of the majority of respondents, as this group is the largest in the target population and also are active consumers. This study has a low response rate from the 55+ age group.

4.4 Irish Consumer's Vitamin D Intake, Supplementation and Health In Context

As is shown in Table 3.2, in this study 42.9% of respondents believed they have an adequate intake of Vitamin D, while 57.1% respondents said that they do not believe they have an adequate intake of Vitamin D. As mention in Section 1, Hill et al.'s study found that in the late winter months 32-55% of females had mild deficiency and 33% of men had mild deficiency (Hill, et al., 2006). The results of females in this study are slightly above, yet close to being in line with Hill et al.'s findings as 59.5% responded that they believe they have inadequate intake of Vitamin D. In this study, 50% of males responded inadequate intake.

In recent years the public's knowledge and awareness of their own health has been on the rise, which could contribute to the elevated responses. As was discussed in the Literature Review in Section 1, the TILDA study found that one in eight or 12.5% of older adults were deficient in Vitamin D. This increased to 25% in winter months. Tilda classified older adults as 50+ years of age (Deane, 2017). As this study was conducted in November, on the verge of winter months, it is expected that values would be between 12.5% and 25%. In the results of this study the older adult age group had 60.8% report that they believed they were deficient in Vitamin D. There was no

scientific measurement for deficiency used in this study which could contribute to the elevated percentage of older adult respondents reporting inadequate intake. Other factors could include the differing age cut off and changes over time, as the TILDA study covered 2009-2016.

Cashman et al.'s study used blood nutrient analysis to confirm Vitamin D deficiency yet has results comparable to this study. In Cashman et al.'s results 40.1%-55% of all respondents reported inadequate intake, in comparison to 57.1% in this study (Cashman, et al., 2012). These findings and comparisons confirm the belief of widespread status of Vitamin D deficiency across the elderly population.

As can be seen in Table 3.3, regarding Supplementation, 46% of total respondents reported taking Vitamin D supplements. The TILDA study found that only 8.5% of the older population is taking Vitamin D supplements, this is much lower than the 45.1% of 55+ year olds that responded taking supplements in this study (Deane, 2017). Cashman et al.'s study had slightly high rates than TILDA, with 17.5% of adults taking Vitamin D supplements, however, this is still much lower than the 48.8% of 25-55 years old taking supplements (Cashman, et al., 2012). Cashman's study and the TILDA study were focused on Irish nationals, while this study is looking into all consumers residing in Ireland, including large numbers of recent immigrants. This difference in target population could contribute to the vast differences in reporting rates. In this study, only 22.2% of the 0-18 years old group reported taking supplements. The FSAI suggests that all babies in Ireland should be given supplements of 5µg/day, as they are especially susceptible to Vitamin D deficiency (Ireland, 2018). Since this study consisted of self-reported answers, the 0-18 range would have consisted mostly of the higher end of that age bracket, but the rate is low for developing youth.

Table 3.4 reported on Irish consumer belief if increased Vitamin D would or would not benefit their health. While there are very few studies that look into consumer belief of increased Vitamin D intake increasing health status, this information gives insight into the consumer acceptance of Vitamin D fortified foods and the want for them within the country. If consumers believe that they will have better health by increasing their Vitamin D intake, then it is likely that they will be inclined to purchased foods boosted in Vitamin D, given other personal beliefs. The results of this study showed that 81.9% of total respondents believed that an increase of Vitamin D intake would benefit their health.

In a study by the Kerry Health and Nutrition Institute claimed that nutritional claims tend to have a higher impact on the older population and on women, as these groups are generally more aware or connected to the nutritional claim (Institute, 2018). This aligns well with the findings of this study, as two of the highest responding groups were females, 85%, and 55+ adults, 84.3%. However, contrastingly, in this study the highest responding group was 19-25 years old.

4.5 Irish Consumers and Fortification In Context

As is shown in Table 3.5, an overwhelming majority of respondents in this study agree with fortification of foodstuffs. Ireland's consumers would be familiar with the idea of fortification of foodstuffs as a market driven fortification system is widely used within the country. This familiarity and prior experience could aid in producing such a high acceptance rate. However, as was discussed in the literature review, there is a current push for clean and transparent labels (Bord Bia, 2019). It is unknown how Vitamin additives are affected by this trend at the moment. As can be seen by the Minister for Health and Children's recent suggestion for mandatory fortification of breads, there is a high acceptance rate of fortification within the Irish political scene as well (Ireland,

2018). This acceptance of the population lends itself for new fortification programs, like the one suggested in this study.

While consumers may overwhelmingly accept the concept of food fortification, when asked directly if they purchase fortified foods, as can be seen in Table 3.6, the rate drops to 70% that reported that they regularly purchase fortified food products. The results of this study showed increasing percentages of people who purchase fortified food products by age group, up to age 55: 33.3%, 60.8%, and 62.1%. Income and financial stability could play a role in this trend, as those in the younger age bracket do not have excessive dispensable incomes to purchase the branded, fortified products.

In research by Teagasc of British and Irish consumers, they found that 27% of consumers were unlikely to purchase functional foods, 36% were undecided and 37% were likely to purchase them (Teasgasc, 2015). No gender of age significance was noted in the Teagasc study, similarly, no significance was noted in this study. While the percentages that reported regularly purchasing fortified foods are lower than those who agree with fortification, the large majority still points in a positive direction for increasing fortification schemes in Ireland.

4.6 Irish Consumers and Processed Meats In Context

Recent research on consumption patterns of meat overall and processed meats in Ireland is sparse. However, as was discussed in the literature review, industry related information can be pieced together and similar diets can be referenced. In the UK, residents ate about 79kg of meat per person in 2016, with consumption of processed cooked bacon and ham rising (Reland, 2018) (Guardian, 2013). As can be seen in Table 3.7, 70.3% of respondents in this study reported consuming processed meats. Similar research in IUNA's Irish nutrition study found that 47% reported eating general

processed meats, and when broken down into products 73% reported eating processed bacon or ham and 39% ate processed sausages (IUNA, 2011). This study was conducted using a dietary journal over the span of four days, suggesting that others who eat processed meats on a monthly basis could have been left out of these figures. Both this study and IUNA's have reports of high processed meat consumption in Ireland.

A separate IUNA study focusing on children found that 91% of children in Ireland consume processed meats, outranking their consumption of fresh meat (IUNA, 2019). This statistic is comparable to the 88.9% of 0-18 years old respondents in this study that reported consuming processed meats. These results go against the expect decrease in processed meat consumption due to highly publicised health concerns and rise in veganism.

4.7 Comparison of Question Respondents In Context

In the remaining results, the respondent's answers to multiple questions were compared to find the percentage of respondents that would fall into the positive categories for both questions analysed. Table 3.8 calculated to determine the number of consumers in Ireland that both agree with fortification and eat processed meats. This information assists in finding how large the market would be for fortified processed meats. The study found that 57.9% of the total respondents both consume process meats and agree with fortification. Since this study does not delve into the frequency of processed meat consumption or the reasoning for disagreement with fortification, there could be an undecided or wavering sector of the population that is unaccounted for in the 57.9%. As Wolf describes in her journal article, before other steps of development and the marketing mix progress, "a profile of the potential customers must be evaluated and a target market developed" (Wolf, 1997). This table and the following are looking to estimate the size of that target population in Ireland.

Tables 3.9 and 3.10 compare the responses of belief of adequate Vitamin D intake and belief that increased intake would benefit health with the acceptance of the proposed fortified food product, processed meats. This information would assist in estimating the impact that the fortification of processed meats would have on a population deficient in Vitamin D or those that would like to increase their intake. In this study it was found that 35.7% of those that believed they do not have adequate intake of Vitamin D would consider buying Vitamin D fortified food products. Table 3.10 also delves into this same area, as it shows that 51.7% of respondents believe that an increase of Vitamin D intake would benefit their health and also would consider buying Vitamin D fortified processed meats. The differences in these percentages could illustrate the population that receive between the deficient level of <25 nmol/L a day and the inadequate level of<50 nmol/L a day (Duffy, et al., 2018). As was discussed in the literature review, in order to implement a market driven fortification scheme, connections between the deficiency and the food product in the target population must be apparent (Barclay, 2018). The 35.7% and 51.7% noted in this study are a notable estimated reach, however, further studies into the consumer acceptance and medical diagnosed deficiencies would be necessary to fully determine its possible impact on reducing vitamin D deficiencies.

Table 3.11 analysed willingness to consider buying more processed meats if they had a health benefit and willingness to consider buying processed meats fortified with Vitamin D and found a significant relationship between the two. This study found that 47.3% of respondents would consider buying more processed meats if they had a health benefit and also would consider Vitamin D fortified processed meats. Contrasting to the findings of this table, a national study on nutritional claims on foods and their effect on purchasing decisions in Ireland reported that healthiness perceptions had little actual influence on purchase decisions (Benson, et al., 2018). Research from Teagasc stated

that stakeholders in the food industry need to market convenience or taste in conjunction with nutrition, as health is not a primary driver for unsure Irish and British consumers (Teasgasc, 2015). This consumer drive for taste, with health as a side benefit, could explain the willingness to purchase more processed meats. There is concern with this high percentage, as due to the health concern already associated with processed meats, the goal of this fortification scheme would not be to increase consumption levels of fortified meats, but rather to provide an improved version of a product that is already being highly consumed in the market.

Finally, Table 3.12 shows the results of the cross of consumers that are already regularly purchasing fortified foods with those that stated they would consider buying Vitamin D fortified processed meat. This crossing illustrates how processed meats will be accepted as a carrier of a fortification nutrient. The results of this test were significant, with 41.1% of consumers regularly purchasing fortified food products willing to consider buying Vitamin D fortified processed meat. As was discussed in the literature review, the perceived fit between the nutrient and the carrier product is a strong predictor of purchasing decisions (Grasso, et al., 2014). This study's results are in line with Tobin et al.'s study of European attitudes towards functional processed meats. In his study between 40% and 60% were willing to consume a functional processed meat; the findings of this study fall within the lower end of Tobin et al.'s brackets (Tobin, et al., 2014).

4.8 Study Strengths and Limitations

This study presented many notable strengths. First, this study serves a creative idea to addressing a notable problem in the health of people residing in Ireland. This study also provides insight into the consumer views on their own Vitamin D status, fortification, and processed meats that could be used for a variety of branching studies. There have been

very limited studies, on consumption rates of processed meats in Ireland and this study is helping to grow this pool of data. In the making of this study, the successful response rate proved to be a major strength in allowing analysis. By including all consumers within Ireland, including those without citizenship, it provided an accurate snapshot of the people the country is serving. While the results did align with many known points, it provided a more up to data and slightly different result for many data points.

However, this study also presented limitations. The descriptive statistics were limited, missing economics factors that could influence purchasing decisions. While the nationality of respondents is unknown, the manner in which the data was collected favoured international and expat groups. This could have led to altered results that did not represent the greater Irish population.

The representativeness of the sample is also unknown. The researcher is unable to determine the rural versus urban response rates, which have historically had very different views and diets. Regarding the variables, processed meats were not defined, and the vastness of this industry will require further research into the specific product(s) to be fortified. Adequate intake of Vitamin D and the term “regular” was also not defined and left to the definition of the respondent, which could vary in levels from person to person.

SECTION 5: CONCLUSION

5.1 Directions for Future Research

As was mentioned in Chapter 2, due to the extensive deficiencies present in the population there is a need to open Vitamin D fortification into additional markets. As the population of Ireland consumes large amounts of processed meats and processed meats are a viable carrier for Vitamin D, they remain a logical option for fortification. According to Teagasc, functional foods should be marketed on a platform of convenience and taste, as health is not a primary driver for many Irish consumers (Teasgasc, 2015). Vitamin D fortified processed meats meet these requirements in their low preparation requirements and attractive taste. However, the health implications of increased processed meat consumption could cause further strain on the health of the population, if consumption were to rise in response. Further research needs to delve into the health implications of fortifying current products and the possibility of improving the status of current processed meats through new product development prior to fortification.

Since consumer acceptance is a main determining factor of the success of market-driven fortification programs, further research needs to be conducted on the market for fortified processed meats and pricing components. As these products are designed to reach a target audience deficient in Vitamin D, it is imperative that they are designed to reach that population. There has recently been high volatility in the rates of meat consumption and recent data in this area is limited. Before further research into this product is invested, there need to be more recent data collected on the consumption of processed meats within Ireland. This study serves as a starting point into researching the impact and acceptance of Vitamin D fortified processed meats.

5.2 Conclusion

This study brought forward a possible new product development to address the known, widespread Vitamin D deficiency in Ireland and began to research into the market acceptance of this product. Although significant relationships were discovered, the findings were not significant enough to declare that this product would be widely accepted in the market or would have a notable reduction on the population's Vitamin D deficiency. The reported consumption rates of processed meats in this study speak to the possible reach of this product, yet the current health factors of processed meats create hesitancy. If the Irish consumption rates of processed meats continue on as widely consumed, processed meats could be a viable fortification vehicle. Perhaps this study's greatest findings are the overall acceptance rates of food fortification in Ireland. This study's findings showed that the consumers in Ireland are willing to and do invest in fortified foods and are aware of the Vitamin D deficiencies.

At a surface level, the study results suggest that future research into Vitamin D fortified processed meats could be viable. It leaves questions such as: to what level of effect would consuming a fortified process meat effect Vitamin D levels? Should all processed meats be fortified or select target products? And when pricing is involved, will consumer's viewpoints change? These are all questions that could be answered with future research in the field.

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SECTION 7: JOURNAL ARTICLE

Vitamin D fortification of processed meat to reduce self-reported deficiencies: Consumer acceptance in the Irish market.

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Abstract:

It is believed that many areas of the world are experiencing a Vitamin D deficiency pandemic. With Ireland's geographic location, genetic characteristics, and other factors; Ireland is a part of the deficiency pandemic. Vitamin deficiencies have historically been handled effectively through food fortification schemes, however additional food markets, like processed meats, need to be assessed for their ability to address the deficiency and consumer acceptance. The aim of this study was to analyse the general consumer acceptance of future Vitamin D fortified, processed meats in the Irish market, in order to reduce deficiencies. The majority of respondents believed that they do not have an adequate intake of Vitamin D, consumed processed meats and an overwhelming majority of respondents also agree with food fortification. The significance of relationships between variables and the percentages of certain responses were tested to make assumptions on the consumer acceptance and impact on Vitamin D deficiency reduction. There was a significant relationship between those who consume processed meats and those that agree with fortification. There was also a significant relationship between those that think their health would increase with increased Vitamin D intake and those that would consider buying processed meats fortified with Vitamin D and between those that regularly purchase fortified foods and those that would consider buying fortified meats fortified with Vitamin D. This finding of this study speaks to the possible success and reach of Vitamin D fortified processed meats.

Keywords: fortification, processed meats, Vitamin D, Ireland, nutrition

1. Introduction

Historically, food fortification has been used as a tool by health professionals and governments to combat population-wide nutritional deficiencies. Codex Alimentarius general principles define fortification as "the addition of one or more essential nutrients to a food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups" (1). In the 1920's in America, fortifying table salt with iodine reduced the widespread outbreaks of goitres. While past successful attempts have been made with Vitamin D fortification in select countries, a deficiency remains strong in other parts of the world.

Internationally, Codex Alimentarius, the Food and Agriculture Organization and the World Health Organization have constructed general guidelines for the addition of vitamins and minerals for foods (2). In order to qualify for fortification the nutrient must fit into one of the three following scenarios: a deficiency of one or more vitamins or minerals in the general or target population that can be shown through clinical or sub clinical evidence or indicated by estimated low levels of intake of nutrients, it contains the potential to boost the nutritional status of the general or target population and/or correct deficiencies in dietary intake due to modifications of dietary habits, or pertains to "evolving generally acceptable scientific knowledge" on the connection between vitamins and minerals in diets and the consequences on human health (3). According to Rosenberg, food fortification is a good strategy to promote adequate intake of nutrients, because it has the advantage of being able to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns (4). Within Ireland, market-driven fortification is used.

1.1 Vitamin D

It is believed that many countries are "currently amid a Vitamin D deficiency pandemic" because of low levels of sunlight exposure (5). Vitamin D deficiencies are widespread across the adult population in Europe, especially the elderly. Historically, Ireland has battled with severe vitamin deficiency due to its geographic location and insufficient sunlight to permit synthesis. There is a dearth of information on the exact levels of Vitamin D deficiency in Ireland. In a study conducted in 2006, in the Irish Medical Journal, females and males of various age groups were observed for Vitamin D deficiency. During the late winter months, depending on the age group, 32-55% of

females had mild deficiency, 2-30% of females had moderate deficiency and 33% of men had mild Vitamin D deficiency (6). The TILDA study found that one in eight older adults were deficient in Vitamin D, which increased to one in four during the winter months. It also showed that the use of supplementation for Vitamin D is low in Ireland, with only 8.5% of the older population taking supplements for Vitamin D (7).

1.2 Processed Meats

Processed meats are convenient, cheap, and have satisfiable taste and are therefore are likely to remain present in the Western diets. IUNA's National Adult Nutrition Study found that when asked to rank food choice motives, respondents put taste as the most important and health and nutrition followed in 77% of adults (8). This study also found that 47% of Irish consumers ate general processed meat products within a span of four days, additionally 73% ate bacon or ham and 39% ate sausages. On average of those that consumed these products, they in took 38g of processed meats, 26g of sausages and 28g of bacon and ham. While consumer trends are quickly shifting, it is expected that a majority of consumers in Ireland still will report consuming processed meats.

Globally, there has been considerable research in recent decades concerning enriching processed meats with healthy ingredients. According to Duffy et al, in order to accommodate dietary diversity, innovatively designed sustainable natural Vitamin D enriched food types are required which will cover a range of food types, reflective of different dietary patterns" (9). As meat is one of the few foods that has naturally occurring Vitamin D (10), and has a high consumption rate within Ireland, it is a considerable choice for future fortification programs. There are mixed reviews on the fortification of meat. According to Hathwar et al., in their review of consumer acceptance of healthier meat products, developing and marketing novel, functional meat products is unconventional and consumers in many countries may not consider these products in the same manner that they would dairy or cereals (11). However, in a 2014 study by Tobin et al., the attitude of over 500 Europeans towards functional (or fortified) processed meats was analysed. In this study, 60% reported that they would consume a functional processed meat, but not pay more for it, while 40% were willing to consume and pay more (12)

The current study aims to analyse the general consumer acceptance of future Vitamin D fortified, processed meats in the Irish market, in order to reduce deficiencies. The null

hypothesis is that Vitamin D fortification of processed meats in the Irish market will not decrease Vitamin D deficiency based on consumer acceptance statistics.

2. Materials and Methods

2.1 Sampling

The data that was used in this study is drawn from original survey responses gathered for the purposes of this research. The study included consumers residing in the Republic of Ireland, of all ages and genders. The inclusion of all consumers created a diverse representation of both rural and suburban consumers, age brackets, incomes and viewpoints. By doing so, it illustrates the shoppers of a general grocery chain, like Tesco, Lidl, Aldi etc in Ireland and the consumers of Irish made products. In order to better represent the day to day Irish market, respondents that reported not living in Ireland were excluded from the study sample.

2.2 Procedure

A random convenience sampling strategy was used to collect responses. The questionnaire was published using an online survey platform. Links from this platform to complete the survey were then posted into social media groups. Respondents completed the survey using their own devices. Due to the nature of this survey, the setting and outside influences could not be controlled. Using this strategy, 392 responses were collected within three weeks. Responses which did not complete all non-demographic questions were removed from the sample, prior to analysis. Four responses were removed, leaving 387 samples.

2.3 Statistical Analysis

IBM's SPSS Version 24 was used to analyse the data for this study. A total of 11 variables, about demographics, vitamin D intake, supplementation, fortification and processed meat from the questionnaire were used in this study. Age was categorized as 0-18, 19-25, 26-55 and 55+. All other variables were yes/no responses. No variable forms were altered following collection. Because of the nominal nature of the variables, Chi Squared Tests were used for all comparative analysis.

3. Results

3.1 Participants

The sample population from this survey represented the target population numbers well. However, due to the nature of collection, the population favours female representatives. The study population consisted of 76% females, 23.7% males, and .3% other. The age brackets used did not consist of equal years, therefore the study population consisted of 2.3% at or below 18 years, 20.4% between 19 and 25 years, 64.2% between 26 and 55 years, and 13.1% above 55 years.

Table 3.1: Descriptive Data on Demographics of the Sample Population

	Valid Denominator	n	%
Where do you reside?	387		
Ireland		387	100.0%
Gender	387		
Male		92	23.8%
Female		294	76.0%
Other		1	0.3%
Age	387		
0-18		9	2.3%
19-25		79	20.4%
26-55		248	64.1%
55+		51	13.2%

3.2 Comparative Results

The responses of different variables were analysed to find the significance of the relationships. This information was then used to deduce whether consumers would accept or reject Vitamin D fortified processed meats in the Irish market.

The findings suggest that there was a significant relationship between consumption habits of processed meats and agreement with fortification (Table 3.2). Of those who consume processed meats, 82.4% or 224 respondents also agree with fortification.

Table 3.2: Irish Consumers' Consumption Habits of Processed Meats by Agreement with Fortification

		Do you consume processed meats?				
	Valid Denominator	**Yes**		**No**		
		n	%	n	%	
Do you agree with fortification?	387					
Yes		224	82.4%	82	71.3%	
No		48	17.6%	33	28.7%	
	Percentage of Total		70.3%		29.7%	**p-value***
						0.015

*Pearson's Chi-Squared

There was a significant relationship between regular purchase of fortified foods and willingness to consider buying processed meats fortified with Vitamin D (Table 3.3). Of those who regularly purchase fortified foods, 67.4% or 159 respondents would consider buying processed meats fortified with Vitamin D.

Table 3.3: Irish Consumers' Consumption Acceptance of Vitamin D Fortified Processed Meats by Belief in Increased Health with Increased Vitamin D

		Would you consider buying processed meats fortified with Vitamin D?				
Do you believe an increase of Vitamin D would benefit your health?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		200	63.1%	117	37.0%	
No		28	40.0%	42	60.0%	
	Percentage of Total		58.9%		41.1%	**p-value***
						>0.001

*Pearson's Chi-Squared

There was also a significant relationship between belief of increased health with increased Vitamin D and willingness to consider buying processed meats fortified with Vitamin D (Table 3.4). Of those who believed an increase of Vitamin D would benefit their health, 63.1% or 200 respondents would consider buying processed meats fortified with Vitamin D.

Table 3.4: Irish Consumers' Consumption Acceptance of Vitamin D Fortified Processed Meats by Willingness to Consider Buying More Processed Meats if they had a Health Benefit

		Would you consider buying processed meats fortified with Vitamin D?				
Would you consider buying more processed meats if they had a health benefit?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		183	81.3%	42	18.7%	
No		45	27.8%	117	72.2%	
	Percentage of Total		58.9%		41.1%	**p-value*** >0.001

*Pearson's Chi-Squared

There was a significant relationship between willingness to consider buying more processed meats if they had a health benefit and willingness to consider buying processed meats fortified with Vitamin D (Table 3.5). Of those who would be willing to buy more, 81.3% or 183 respondents would consider buying processed meats fortified with Vitamin D.

Table 3.5: Irish Consumers' Consumption Acceptance of Vitamin D Fortified Processed Meats by Regular Purchasing of Fortified Foods

		Would you consider buying processed meats fortified with Vitamin D?				
Do you regularly purchase fortified foods?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		159	67.4%	77	32.6%	
No		69	45.7%	82	54.3%	
	Percentage of Total		58.9%		41.1%	**p-value*** >0.001

*Pearson's Chi-Squared

These significant relationships all point the Vitamin D fortified processed meats positively affecting the Vitamin D levels of Irish consumers.

However, there was an insignificant relationship between belief of adequate intake of Vitamin D and willingness to consider buying processed meat fortified with Vitamin D (Table 3.6). Of those who believed they did not have an adequate intake of Vitamin D; 62.4% or 138 respondents would consider buying processed meats fortified with Vitamin D.

Table 3.6: Irish Consumers' Acceptance of Vitamin D Fortified Processed Meats by Adequate Vitamin D Intake

		Would you consider buying processed meats fortified with Vitamin D?				
Do you believe you have adequate intake of Vitamin D?	**Valid Denominator**	**Yes**		**No**		
		n	%	n	%	
	387					
Yes		90	54.2%	76	45.8%	
No		138	62.4%	83	37.6%	
	Percentage of Total		58.9%		41.1%	**p-value***
						0.104

*Pearson's Chi-Squared

4. Discussion

This study set up to evaluate the current believes of consumers on Vitamin D health, fortification and processed meats; with the ultimate aim to predict if Vitamin D fortified processed meats would be an effective solution to reduce self-reported deficiencies of Vitamin D in the Irish market. The Vitamin D status of the population, acceptance of fortification and consumption of processed meats was assessed against different demographics and against each other. It was expected that the answers to these questions would provide insight into the consumer acceptance of Vitamin D fortified processed meats and how the addition of this product would address Vitamin D deficiencies. This insight would be useful for health officials as well as product manufacturers.

The number of consumers in Ireland that both agree with fortification and eat processed meats was calculated to aid in finding how large the market would be for fortified processed meats. This study found that 57.9% of the total respondents both consume

process meats and agree with fortification. Since this study does not delve into the frequency of processed meat consumption or the reasoning for disagreement with fortification, there could be an undecided or wavering sector of the population that is unaccounted for in the 57.9%. As Wolf describes in her journal article, before other steps of development and the marketing mix progress, "a profile of the potential customers must be evaluated and a target market developed" (13). This information helps to estimate the size of that target population in Ireland.

The responses of belief of adequate Vitamin D intake crossed with belief that increased intake would benefit health with the acceptance of the proposed fortified food product, processed meats, assists in estimating the impact that the fortification of processed meats would have on the population deficient in Vitamin D. In this study it was found that 35.7% of those that believed they do not have adequate intake of Vitamin D would consider buying Vitamin D fortified food products. The results also show that 51.7% of respondents believe that an increase of Vitamin D intake would benefit their health and also would consider buying Vitamin D fortified processed meats. The differences in these percentages could illustrate the population that receive between the deficient level of <25 nmol/L a day and the inadequate level of<50 nmol/L a day (9). In order to implement a market driven fortification scheme, connections between the deficiency and the food product in the target population must be apparent (14). The 35.7% and 51.7% noted in this study are a notable estimated reach.

In this study, willingness to consider buying more processed meats if they had a health benefit and willingness to consider buying processed meats fortified with Vitamin D had a significant relationship. This study found that 47.3% of respondents would consider buying more processed meats if they had a health benefit and also would consider Vitamin D fortified processed meats. Contrasting to these findings, a national study on nutritional claims on foods and their effect on purchasing decisions in Ireland reported that healthiness perceptions had little actual influence on purchase decisions (15). Research from Teagasc stated that stakeholders in the food industry need to market convenience or taste in conjunction with nutrition, as health is not a primary driver for unsure Irish and British consumers (16). Consumers' drive for taste, with health as a side benefit could explain the willingness to purchase more processed meats. There is concern with this high percentage, as due to the health concerns already associated with processed meats, the goal of this fortification scheme would not be to increase

consumption levels of fortified meats, but rather to provide an improved version of a product that is already being highly consumed in the market.

The results of the cross of consumers that are already regularly purchasing fortified foods with those that stated they would consider buying Vitamin D fortified processed meats illustrates how processed meats will be accepted as a carrier of a fortification nutrient. The results of this test were significant, with 41.1% of consumers regularly purchasing fortified food products willing to consider buying Vitamin D fortified processed meat. The perceived fit between the nutrient and the carrier product is a strong predictor of purchasing decisions (17). This study's results are in line with Tobin et al.'s study of European attitudes towards functional processed meats. In his study between 40% and 60% were willing to consume a functional processed meat; the findings of this study fall within the lower end of Tobin et al.'s brackets.

This study presented many notable strengths. First, this study serves a creative idea to addressing a notable problem in the health of people residing in Ireland. This study also provides insight into the consumer views on their own Vitamin D status, fortification, and processed meats that could be used for a variety of branching studies. There have been very limited studies, on consumption rates of processed meats in Ireland and this study is helping to grow this pool of data. In the making of this study, the successful response rate proved to be a major strength in allowing analysis. By including all consumers within Ireland, including those without citizenship, it provided an accurate snapshot of the people the country is serving. While the results did align with some known points, it provided a more up to data and slightly different result for many data points.

However, this study also presented limitations. The descriptive statistics were limited, lacking economics factors that could influence purchasing decisions. While the nationality of respondents is unknown, the manner in which the data was collected favoured international and expat groups. This could have led to altered results that did not represent the greater Irish-born population. The representativeness of the sample is also unknown. The researcher is unable to determine the rural versus urban response rates, which have historically had very different views and diets. Regarding the variables, processed meats were not defined, and the vastness of this industry will require further research into the specific product(s) to be fortified. Adequate intake of Vitamin D and the

term “regular” were also not defined and left to the definition of the respondent, which could vary in levels from person to person.

5. Conclusion

Though significant relationships were discovered he findings were not significant enough to declare that this product would be widely accepted in the market or would have a notable reduction on the population’s Vitamin D deficiency. The reported consumption rates of processed meats in this study speak to the possible reach of this product, yet the current health factors of processed meats create hesitancy. Further studies into the consumer acceptance and medical diagnosed deficiencies would be necessary to fully determine the possible impact Vitamin D fortified processed meats would have on reducing vitamin D deficiencies.

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SECTION 8: APPENDICES

Appendix A: Questionnaire

Master Thesis-Vitamin D Fortification of Foodstuff

Introduction

All responses are confidential. Thank you in advance for taking part in this survey.

Demographics

Q1. Where do you reside?

☐ Ireland ☐ Other

Q2. What gender do you define as?

☐ Male ☐ Female ☐ Other

Q3. What is your age?

☐ 0-18 ☐ 19-25 ☐ 26-55 ☐ 55+

Questions Continued

Q4. Do you believe you have adequate intake of Vitamin D?

☐ Yes ☐ No

Q5. Do you take Vitamin D supplements?

☐ Yes ☐ No

Q6. Do you believe an increase of Vitamin D consumption would benefit your health?

☐ Yes ☐ No

Q7. Per Codex definition, fortification is "The addition of one or more essential nutrients to a food whether or not it is normally contained in the food, for the purpose of preventing

or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups"

Do you agree with fortification of foodstuffs?

☐ Yes ☐ No

Q8. Do you regularly purchase fortified food products? i.e. cereals, salt, milk, etc.

☐ Yes ☐ No

Q9. Do you consume processed meats? i.e. rashers, sausages, ham, cured meats, etc

☐ Yes ☐ No

Q10. Would you be more likely to consume processed meats if they had a health benefit?

☐ Yes ☐ No

Q11. Would you consider buying processed meat fortified with Vitamin D?

☐ Yes ☐ No

Appendix B: List of Tables

Appendix C: Author Guidelines for Journal Article-Nutrients

General Considerations

- **Research manuscripts** should comprise:
    - **Front matter**: Title, Author list, Affiliations, Abstract, Keywords
    - **Research manuscript sections**: Introduction, Materials and Methods, Results, Discussion, Conclusions (optional).
    - **Back matter**: Supplementary Materials, Acknowledgments, Author Contributions, Conflicts of Interest, **References**.
- **Review manuscripts** should comprise the **front matter**, literature review sections and the **back matter**. The template file can also be used to prepare the front and back matter of your review manuscript. It is not necessary to follow the remaining structure. Structured reviews and meta-analyses should use the same structure as research articles and ensure they conform to the **PRISMA** guidelines.
- **Case reports** should include a succinct introduction about the general medical condition or relevant symptoms that will be discussed in the case report; the case presentation including all of the relevant de-identified demographic and descriptive information about the patient(s), and a description of the symptoms, diagnosis, treatment, and outcome; a discussion providing context and any necessary explanation of specific treatment decisions; a conclusion briefly outlining the take-home message and the lessons learned.
- **Graphical abstract:** Authors are encouraged to provide a graphical abstract as a self-explanatory image to appear alongside with the text abstract in the Table of

Contents. Figures should be a high-quality image in any common image format. Note that images displayed online will be up to 11 by 9 cm on screen and the figure should be clear at this size.

- **Abbreviations** should be defined in parentheses the first time they appear in the abstract, main text, and in figure or table captions and used consistently thereafter.
- **SI Units** (International System of Units) should be used. Imperial, US customary and other units should be converted to SI units whenever possible
- **Accession numbers** of RNA, DNA and protein sequences used in the manuscript should be provided in the Materials and Methods section. Also see the section on **Deposition of Sequences and of Expression Data**.
- **Equations:** If you are using Word, please use either the Microsoft Equation Editor or the Math Type add-on. Equations should be editable by the editorial office and not appear in a picture format.
- **Research Data and supplementary materials:** Note that publication of your manuscript implies that you must make all materials, data, and protocols associated with the publication available to readers. Disclose at the submission stage any restrictions on the availability of materials or information. Read the information about **Supplementary Materials** and Data Deposit for additional guidelines.
- **Preregistration:** Where authors have preregistered studies or analysis plans, links to the preregistration must be provided in the manuscript.

- **Guidelines and standards:** MDPI follows standards and guidelines for certain types of research. See **https://www.mdpi.com/editorial_process** for further information.

Front Matter

These sections should appear in all manuscript types

- **Title:** The title of your manuscript should be concise, specific and relevant. It should identify if the study reports (human or animal) trial data, or is a systematic review, meta-analysis or replication study. When gene or protein names are included, the abbreviated name rather than full name should be used.
- **Author List and Affiliations:** Authors' full first and last names must be provided. The initials of any middle names can be added. The PubMed/MEDLINE standard format is used for affiliations: complete address information including city, zip code, state/province, and country. At least one author should be designated as corresponding author, and his or her email address and other details should be included at the end of the affiliation section. Please read the **criteria to qualify for authorship**.
- **Abstract:** The abstract should be a total of about 200 words maximum. The abstract should be a single paragraph and should follow the style of structured abstracts, but without headings: 1) Background: Place the question addressed in a broad context and highlight the purpose of the study; 2) Methods: Describe briefly the main methods or treatments applied. Include any relevant preregistration numbers, and species and strains of any animals used. 3) Results: Summarize the article's main findings; and 4) Conclusion: Indicate the main conclusions or interpretations. The abstract should be an objective representation

of the article: it must not contain results which are not presented and substantiated in the main text and should not exaggerate the main conclusions.

- **Keywords:** Three to ten pertinent keywords need to be added after the abstract. We recommend that the keywords are specific to the article, yet reasonably common within the subject discipline.

Research Manuscript Sections

- **Introduction:** The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance, including specific hypotheses being tested. The current state of the research field should be reviewed carefully and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the workand highlight the main conclusions. Keep the introduction comprehensible to scientists working outside the topic of the paper.

- **Materials and Methods:** They should be described with sufficient detail to allow others to replicate and build on published results. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited. Give the name and version of any software used and make clear whether computer code used is available. Include any pre-registration codes.

- **Results:** Provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

- **Discussion:** Authors should discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible and limitations of the work highlighted. Future research directions may also be mentioned. This section may be combined with Results.
- **Conclusions:** This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.
- **Patents:** This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

Back Matter

- **Supplementary Materials:** Describe any supplementary material published online alongside the manuscript (figure, tables, video, spreadsheets, etc.). Please indicate the name and title of each element as follows Figure S1: title, Table S1: title, etc.
- **Acknowledgments:** All sources of funding of the study should be disclosed. Clearly indicate grants that you have received in support of your research work and if you received funds to cover publication costs. Note that some funders will not refund article processing charges (APC) if the funder and grant number are not clearly and correctly identified in the paper. Funding information can be entered separately into the submission system by the authors during submission of their manuscript. Such funding information, if available, will be deposited to **FundRef** if the manuscript is finally published.

- **Author Contributions:** Each author is expected to have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; or have drafted the work or substantively revised it; AND has approved the submitted version (and version substantially edited by journal staff that involves the author's contribution to the study); AND agrees to be personally accountable for the author's own contributions and for ensuring that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and documented in the literature.

  For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; Methodology, X.X.; Software, X.X.; Validation, X.X., Y.Y. and Z.Z.; Formal Analysis, X.X.; Investigation, X.X.; Resources, X.X.; Data Curation, X.X.; Writing – Original Draft Preparation, X.X.; Writing – Review & Editing, X.X.; Visualization, X.X.; Supervision, X.X.; Project Administration, X.X.; Funding Acquisition, Y.Y.", please turn to the **CRediT taxonomy** for the term explanation. For more background on CRediT, see **here**. "**Authorship must include and be limited to those who have contributed substantially to the work. Please read the section concerning the criteria to qualify for authorship carefully**".

- **Conflicts of Interest:** Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results. If there is no conflict of interest, please state "The authors declare no conflict of interest." Any

role of the funding sponsors in the choice of research project; design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish the results must be declared in this section. *Nutrients* does not publish studies funded by the tobacco industry. Any projects funded by pharmaceutical or food industries must pay special attention to the full declaration of funder involvement. If there is no role, please state "The sponsors had no role in the design, execution, interpretation, or writing of the study".

- **References:** References must be numbered in order of appearance in the text (including table captions and figure legends) and listed individually at the end of the manuscript. We recommend preparing the references with a bibliography software package, such as **EndNote**, **ReferenceManager** or **Zotero** to avoid typing mistakes and duplicated references. We encourage citations to data, computer code and other citable research material. If available online, you may use reference style 9. below.
- Citations and References in Supplementary files are permitted provided that they also appear in the main text and in the reference list.

In the text, reference numbers should be placed in square brackets [ ], and placed before the punctuation; for example [1], [1–3] or [1,3]. For embedded citations in the text with pagination, use both parentheses and brackets to indicate the reference number and page numbers; for example [5] (p. 10). or [6] (pp. 101–105).

The reference list should include the full title, as recommended by the ACS style guide. Style files for **Endnote** and **Zotero** are available.

References should be described as follows, depending on the type of work:

 Journal Articles:

1. Author 1, A.B.; Author 2, C.D. Title of the article. *Abbreviated Journal Name* **Year**, *Volume*, page range.

 Books and Book Chapters:

2. Author 1, A.; Author 2, B. *Book Title*, 3rd ed.; Publisher: Publisher Location, Country, Year; pp. 154–196.

3. Author 1, A.; Author 2, B. Title of the chapter. In *Book Title*, 2nd ed.; Editor 1, A., Editor 2, B., Eds.; Publisher: Publisher Location, Country, Year; Volume 3, pp. 154–196.

 Unpublished work, submitted work, personal communication:

4. Author 1, A.B.; Author 2, C. Title of Unpublished Work. status (unpublished; manuscript in preparation).

5. Author 1, A.B.; Author 2, C. Title of Unpublished Work. *Abbreviated Journal Name* stage of publication (under review; accepted; in press).

6. Author 1, A.B. (University, City, State, Country); Author 2, C. (Institute, City, State, Country). Personal communication, Year.

 Conference Proceedings:

7. Author 1, A.B.; Author 2, C.D.; Author 3, E.F. Title of Presentation. In *Title of the Collected Work* (if available), Proceedings of the Name of the Conference, Location of Conference, Country, Date of Conference; Editor 1, Editor 2, Eds. (if available); Publisher: City, Country, Year (if available); Abstract Number (optional), Pagination (optional).

- Thesis:

8. Author 1, A.B. Title of Thesis. Level of Thesis, Degree-Granting University, Location of University, Date of Completion.

- Websites:

9. Title of Site. Available online: URL (accessed on Day Month Year).

Unlike published works, websites may change over time or disappear, so we encourage you create an archive of the cited website using a service such as **WebCite**. Archived websites should be cited using the link provided as follows:

10. Title of Site. URL (archived on Day Month Year).